

NATIONAL TRANSPORTATION SAFETY BOARD  
Office of Aviation Safety  
Washington, D.C. 20594

April 03, 2000

Structures Group Chairperson's Factual of Investigation

DCA00MA006

A. ACCIDENT

Location: 60 miles south of Nantucket, Massachusetts

Date: October 31, 1999

Time: 0150 Eastern Standard Time (EST)

Airplane: Boeing 767-366ER, SU-GAP  
Operated by EgyptAir

B. STRUCTURES GROUP

Chairperson: Lorenda Ward  
National Transportation Safety Board  
Washington, D.C.

Member: Robert L. Whittington  
Boeing Company  
Seattle, Washington

Member: Kirby W. Johnson, P.E.  
Boeing Company  
Seattle, Washington

Member: Arnold A. Reimer, P.E.  
Boeing Company  
Seattle, Washington

Member: Amr El Semaary  
EgyptAir  
Cairo, Egypt

Member: Sayed Madkour  
EgyptAir  
Cairo, Egypt

Member: Esmail Ibrahim  
Egyptian Civil Aviation Authority  
Cairo, Egypt

### C. SUMMARY

About 0150 eastern standard time (EST), on October 31, 1999, a Boeing 767-366ER, SU-GAP, operated by EgyptAir, as flight 990, crashed into the Atlantic Ocean about 60 miles south of Nantucket, Massachusetts. EgyptAir flight 990 was being operated under the provisions of Egyptian Civil Aviation Regulations Part 121 and United States Title 14 Code of Federal Regulations Part 129 as a scheduled, international flight from John F. Kennedy Airport (JFK), New York, New York to Cairo International Airport in Cairo, Egypt. The flight departed JFK about 0122 EST, with 4 flightcrew members, 10 flight attendants, and 203 passengers on board. There were no survivors. The airplane was destroyed by impact forces.

Supporting documentation, including a major assembly breakdown (Appendix A), hangar floor plan (Appendix B), fuselage stations diagram (Appendix C), wing stations diagram (Appendix D), engine pylon diagram (Appendix E), horizontal stabilizer stations (Appendix F), vertical fin stations (Appendix G), photographs (Appendix H), and tables (Appendix I) is attached.

### D. DETAILS OF THE INVESTIGATION

#### 1.0 Wreckage Distribution, Recovery and Hangar Floor Plan

Sonar mapping of the airplane wreckage site depicted two distinct debris fields, labeled East and West. The East debris field was 83 meters by 73 meters and the West debris field was 62 meters by 66 meters. The distance from center to center of the debris fields was approximately 350 meters.

Floating debris from the airplane was recovered by the U.S. Coast Guard on the morning of October 31, 1999 and continued until November 07, 1999. The ships crew recorded the latitude and longitude of where the debris was recovered. The recovered floating debris was unloaded at Quonset Point, Rhode Island where the Rhode Island Medical Examiner, Federal Bureau of Investigation (FBI) and the National

Transportation Safety Board (NTSB) checked for human remains and any signs of fire or explosion damage. As each ship came in the floating debris was assigned lot numbers. A crane was brought in to help unload the ships.

A hindrance to the land and water activities was the weather conditions. Initially the debris was laid outside to dry due to fuel contamination. But with the high winds and rain, a temporary shelter (tent) was erected for the drying, tagging and documenting of the floating debris. Since portable heaters were used inside the tent, one had to wear a respirator to protect against carbon monoxide poisoning. To prevent explosive detection contamination one had to wear booties and gloves. Tyvek was also utilized. The debris was tagged by the FBI and then documented by representatives from Boeing and the NTSB.

The flight data recorder and the cockpit voice recorder were recovered by a Remote Operated Vehicle (ROV). A commercial vessel was leased by the NTSB to recover the wreckage from the ocean floor. On December 22, 1999 the recovered wreckage was unloaded at Quonset Point. Approximately 70% of the airplane was recovered. This number was provided by the Investigator-in-Charge (IIC) and was determined by weighing the sea containers as they came off the ship.

In less than 24 hours, Oceaneering and the FBI had the ship unloaded, the wreckage rinsed and laid out in the hangar. This process involved the use of moveable cranes and a front loader. The sea containers full of wreckage were lifted off the ship and moved to the temporary wash station. Trial and error proved that we needed to have a more thorough rinse of the wreckage followed by a second rinse with the sea containers being tilted and water sprayed into the container. The sea containers were then moved into the hangar where they were tilted and the wreckage dumped onto the hangar floor. A front loader was used to help push the wreckage out on the floor along with manually pushing and pulling the wreckage with rakes and shovels. The wreckage was arranged so that it was only one layer thick with space enough for the wreckage to dry out over the holidays. After the wreckage from a container was spread out, the area was taped off. A total of twelve sea containers were unloaded.

## 2.0 Structures Examination

The structures group met from January 6 - January 17, 2000 to examine the wreckage that had been laid out on the hangar floor. The wreckage now had to be sorted, refer to the major assembly diagram (Appendix A). The main areas of focus were the fuselage, wings, tail, and landing gear with the main objective to identify the four corners of the airplane. Color scheme, weight of material, part numbers, and station

numbers were all utilized to identify where a piece/part was to be placed. If a piece of wreckage was identified as a fuselage or tail piece but the exact location could not be determined, then the piece was placed in the miscellaneous fuselage or miscellaneous tail section. Not all of the wreckage was segregated. There is still some wreckage laid out on the hangar floor that is unidentified.

The limited space available in the hangar made for some creative moving of wreckage once the sorting began, refer to the hangar floor diagram (Appendix B). The structures group did a first pass and pulled out all the large pieces of the cabin interior, cargo bins, and cargo manifest to clear up floor space and to expose more wreckage. These pieces were loaded into a U-Haul and moved to building 18. Once the sorting of the remaining wreckage was completed, then each section was documented. A visual approximation of the amount of wreckage for each section was also documented.

## 2.1 Fuselage

The fuselage pieces examined were recovered from the East debris field. In general, the percent of identifiable fuselage pieces increases moving aft. The size of the pieces also increase moving aft.

The fuselage is a pressurized semi-monocoque structure formed from circumferential frames, longitudinal stringers, and skin. Pressure bulkheads at the forward and aft ends of the fuselage form a pressure vessel. The fuselage is divided horizontally by the floor, which is built up from beams and panels. The primary materials are 2024 and 7075 aluminum alloys. The floor panels are honeycomb composite. Boeing divides the 767 fuselage into five sections: section 41, section 43, section 45, section 46 and section 48. Refer to the fuselage station diagram (Appendix C).

Section 41 is the forward fuselage section that contains the radar antenna, flight deck, forward entry door, galley door, nose wheel well and the electronic equipment compartment. Section 43 contains the forward portion of the passenger cabin and the forward cargo compartment, which has a door on the right side. Section 45 contains the center portion of the passenger cabin, which has two overwing escape hatches. The space below the floor includes the wing center section, air conditioning bays, and wheel well. Section 46 contains the aft portion of the passenger cabin, windows between the frames, and aft entry and galley doors. Below the floor is the aft cargo compartment with a door on the right side and a door for bulk cargo on the left side. This section terminates at the aft pressure bulkhead. Section 48 contains the auxiliary power unit (APU) and supports the horizontal and vertical tail.

The upper and lower portion of the fuselage sections were identifiable by the color of the skins; green for the upper and white for the lower.

#### 2.1.1 Section 41 - fuselage station 92.5 to 434.00

Very little of the structure from section 41 was recovered and identified. The identified structure was approximately 1% of the total structure in this area. The majority of the recovered and identified structure consists of the heavy cockpit window frames. The number one, or forward, window frame was constructed primarily of titanium. The number two and three window frames were heavy aluminum forgings providing high strength structure. These window frames were typically fractured near the corners or structural intersections and range from 18 inches to 40 inches long. Approximately 85% of the cockpit window frames were recovered and identified; comprising pieces from every window. Small fragments of window material were in the cockpit window frames. None of the six passenger windows were identified.

There were three short frame sections identified from section 41. These frame sections were from the aft part of section 41 in the crown area. The sections were 2 feet to 3 feet long and the deformation was consistent with failure due to high-speed impact.

None of the window belts<sup>1</sup> in the fuselage passenger section were identified and although some door surround structure was recovered, none could be identified as the passenger entry door for section 41. Some small pieces of the nose landing gear wheel well were recovered; the largest was approximately 10 inches by 14 inches. No directionality could be determined from the recovered wreckage.

There was no evidence of any pre or post impact fire damage and all fractures were consistent with failures generated by a high-speed impact. None of the fracture surfaces examined exhibited any sign of pre-existing fatigue or corrosion damage.

#### 2.1.2 Section 43 - fuselage station 434.00 to 785.9

Section 43 is the constant diameter fuselage section between the nose section and the wing. It begins after the 3rd passenger window and ends at the wing front spar. Approximately 1% to 2% of the structure from section 43 was recovered and identified. Of this structure, approximately 60% was heavy door surround structure, 30% was window belts, 8% crown skins, and about 2% cargo floor and keel beam extensions.

The majority of the structure identified, consists of the heavy door surround structure from the left and right number two access doors and the forward cargo door. This structure fractured in such a way that the

---

<sup>1</sup> Window belt is the heavy structure surrounding the passenger windows.

corners of the doors were essentially intact with the fractures just beyond the tangent points. The pieces were generally about 4 feet by 6 feet.

There were some fuselage panels with no frames, and very few stringers. These panels were all from the crown area of section 43. One of the skins had the VHF antenna located at the crown with the electronics still attached. These skins were approximately 3 feet by 4 feet. None of the skins identified were from the lower part of the fuselage. There were five full or partial window frames identified as section 43. One section of window frame had tight curling in the skin between the windows. No window material was in any of the frames.

There were a few separated frame segments identified as section 43. These were typically 2 feet in length and were fractured at the shear ties and skin attachments.

There was no evidence of any pre or post impact fire damage and all fractures were consistent with failures generated by a high-speed impact. There was no prevailing directionality to the failures. None of the fracture surfaces examined exhibited any sign of pre-existing fatigue and there was some light corrosion damage on a few parts where the primer and paint were missing. There was no evidence of "pillowing" distortion. There was no evidence of foreign impact damage.

#### 2.1.3 Section 45 - fuselage station 785.9 to 1065.00

Section 45 of the fuselage is the area above the wing and wheel well and includes the main wheel well itself. The identifiable wreckage from section 45 includes the wheel well bulkhead support frames, overwing longerons, landing gear support fittings, keel beam lower chord segments, window belt forgings and some small segments of skin panels. Approximately 5% of section 45 structure was recovered and identified.

The majority, approximately 85%, of that structure came from the wheel well area. There was a high degree of fragmentation to these pieces from the wheel well with the exception of the left and right fittings that attach the hangar link for the main landing gear beam. The failures were consistent with the rest of the fuselage and consistent with damage from a high-speed impact. No general sense of directionality was evident from these fractures.

There were eight window frames or partial window frames from the passenger section of section 45 identified. The largest section had three window forgings and in general the window belts in this area failed between the windows and at the upper and lower stringers but left the forgings intact. There was no window material in any of the window forgings. There was no general directionality to the failures. Section 45 normally has twenty-two window frames.

There were two skin panel segments identified as section 45. One was a light panel from the crown area about 3 feet by 4 feet, which was deformed and had a light layer of corrosion where the primer and paint was missing. The largest section of fuselage skin was 3 feet by 6 feet and includes the upper edge of the overwing exit hatch. The fractures were consistent with the rest of the wreckage and with a high-speed impact. There were a few separated frame segments identified as section 45. These were typically 2 feet in length and had fractured at the shear ties and skin attachments.

There was no evidence of any pre or post impact fire damage and all fractures were consistent with failures generated by a high-speed impact. There was no prevailing directionality to the failures. None of the fracture surfaces examined exhibited any sign of pre-existing fatigue. There was some light surface corrosion damage on a few parts where the primer and paint were missing. There was no evidence of "pillowing" distortion. There was no evidence of foreign impact damage.

#### 2.1.4 Section 46 - fuselage station 1065.00 to 1582.00

This section of the fuselage broke in several large pieces, approximately 3 feet to 4 feet by 5 feet in size. Approximately 25 % of section 46 was identified in the recovered wreckage. There were approximately sixteen windows identified with the majority of the windows fractured at midspan and all of the window material was gone. Normally there are forty-six windows in this section. The window belt panels are described below.

There was a window belt panel of skin, measuring 6 feet by 3 feet, which had three window frame forgings. Two of the window frames were intact. No frame segments were present.

There was a window belt panel of skin, measuring 5 feet by 7 feet that had four window openings. Three of the four window openings were fractured. The panel was folded opposite to the fuselage panel curvature.

There was a window belt panel of skin, with four fractured window frames, that was heavily damaged and estimated to be 4 feet by 8 feet before being damaged.

There was a window belt panel of skin, measuring 2 feet by 6 feet, with one fractured window frame, which contained a panel splice; the splice fittings were deformed but not visibly fractured.

There was a window belt panel of skin with four window frame forgings that had two frames intact.

There was a 4 feet by 5 feet segment of the crown with stringer elements still attached. The panel was crumpled with local bending fractures at the stringer splice fitting locations.

There was a panel measuring 5 feet by 8 feet with the stringers still attached but with part of the stringers broken. No frames were present. The panel skin and stringers were sliced as if impacted by another object.

There was a 4 feet by 8 feet crown panel mangled with some broken stringers. There was a lower lobe panel, measuring 9 feet by 7 feet that contained the cargo loading light housing. There was a 5 feet by 11 feet "L" shaped panel that contained the upper sill of the right side cargo door.

There was an upper lobe panel measuring 8 feet by 8 feet with stringers and one small piece of frame intact. There was a 10 feet by 2-½ feet piece of the lower lobe keel chord extension. The panel contains the keel chord extension extruded section and the three adjacent stringers. Approximately twelve other smaller skin panel pieces were identified, which averaged 3 feet by 3 feet.

Almost all of the frames that attach to the skins were missing. Most of the shear ties that attach the frame to skins were fractured. The majority of the stringers were attached to the fuselage skin and were fractured at various locations. Compression damage on the stringers was observed to be in the fore and aft direction at some locations. Some pieces exhibited corkscrew curling from the outside to inside. The curls were tight with three curls within a two-inch diameter.

A few loose frame fragments were identified by station number or part number, the largest being three feet long.

The largest piece of fuselage recovered was the door surround structure from the number three left door. This included the aft frame and the entire lower doorsill extending three frames forward and two frames aft of the door. This was an "L" shaped piece, measuring 10 feet by 10 feet

There was no evidence of any pre or post impact fire damage and all fractures were consistent with failures generated by a high-speed impact. There was no prevailing directionality to the failures. None of the fracture surfaces examined exhibited any sign of pre-existing fatigue. There was no evidence of "pillowing" distortion. There was no evidence of foreign impact damage. There was no evidence of pre-existing corrosion.

#### 2.1.5 Section 48 – fuselage station 1582.00 to 1952.00

The portion of the wreckage recovered and identified as Section 48 structure was approximately 25% of the section. Identifiable portions consist of the pressure dome pieces, skin portions, portions of bulkheads, frame fragments, the APU firewall and plenum, tail cone



sections and portions of the APU service doors. The APU inlet door and the aft service hatch were also found.

The pieces identified as part of the aft pressure dome comprised approximately 30 % of the complete dome. These pieces were separate from the section 48 pieces. There were large pieces of the Y-chord<sup>2</sup> circumferential frame as follows: three pieces about 60 inches long, 4 pieces about 40 inches long, with the remaining pieces less than 20 inches long. The largest fragments of the dome were 3 feet by 3 feet. Most of the dome pieces were in the 2 feet by 2 feet range. The portions typically consisted of a segment of the Y-chord with the tension splice fittings intact, pieces of section 46 and 48 skins, and a portion of the pressure dome skin.

There was a skin panel, which included a segment of the station 1809 bulkhead and one frame forward and two frames aft. This piece was 41 inches wide and had intact stringer splice fittings and two attached machined back-up fittings.

There was a skin panel 39 inches by 82 inches between the horizontal tail cutout and the APU inlet door cutout on the upper right side. Fragments of bulkhead 1725 chord were attached. The stringer splice fittings were intact.

There was a skin panel 35 inches by 60 inches, which extended from the APU firewall to the station 1809.5 bulkhead. A portion of the firewall and the bulkhead were attached along with a two-piece portion of a frame. There was a second smaller segment 22 inches by 22 inches between the firewall and the bulkhead.

There was a skin panel that measured 22 inches by 48 inches and included station 1767.25. This piece was bent in half. There were skin panel pieces without specific locations. Included in this group were a 37 inches by 76 inches skin segment with stringers and a portion of frame attached and 15 other miscellaneous pieces approximately 1 foot by 2 feet in size.

The forward portion of the vertical fin dorsal fairing was found. The fairing was complete but deformed. The attachment fasteners were fractured.

The bulkheads at stations 1725.5 and 1702 had machined upper portions and built up lower portions. Six pieces of the machined portion of station 1702 bulkhead were identified; the largest being 3 feet long and the average size was 2 feet by 2 feet. The splices to the built up adjoining portions were intact. The station 1725.5 bulkhead had eight pieces of the machined portion identified; the longest being 2 ½ feet long. The average size was about 1-½ feet by 2 feet. Both had portions of the

---

<sup>2</sup> The Y-chord forms the section 46 to section 48 skin splice and the pressure bulkhead core and the station 1582 frame.

shear tie elements that connect the bulkhead to the skin panels attached but no skin or stringer elements. Upper portions of both bulkheads that attach to the vertical fin structure were broken off. There was surface corrosion on the forward face of the web portion of the built up part where paint was missing.

The largest piece identified was a portion of the web 42 inches by 44 inches with the systems components still attached. There was also a separate 1-foot by 3 feet segment and a separate back-up fitting.

There were six loose frame segments identified as belonging to section 48. They range in size from 20 inches to 40 inches in length.

Identifiable pieces of the tail cone included the upper portion 82 inches long from station 1848.35 to station 1890.1, with the lap splice in the crown. There was a portion 41 inches long, which includes stations 1890.1 and 1898.45. There was a portion of tail cone crown 36 inches by 36 inches. This portion was crushed accordion fashion in the longitudinal direction.

Three pieces of the APU service door were identified. The pieces included the locator pins and matching sockets, also the latch hooks and fittings on mating door edges. The aft edge of the APU door at station 1906 was the aft most fuselage element identified.

Approximately 90% of the APU surround structure and firewall was present. The upper right side was split open. There were 5 of the 6 attach fittings still intact. Pieces of the firewall were attached to other elements previously described.

There was no evidence of any pre or post impact fire damage and all fractures were consistent with failures generated by a high-speed impact. There was no prevailing directionality to the failures. None of the fracture surfaces examined exhibited any sign of pre-existing fatigue and there was some light corrosion damage on a few parts where the primer and paint were missing. There was no evidence of "pillowing" distortion. There was no evidence of foreign impact damage.

#### 2.1.6 Miscellaneous

The miscellaneous category is for fuselage pieces that could not be identified by fuselage section. Miscellaneous fuselage items were evenly distributed between upper and lower lobe. The category was estimated to include 25 % of the fuselage structure. These pieces were collected in three separate areas in the hanger. Miscellaneous door parts were also collected in a separate area in the hanger.

Six large fuselage panels were in the collection, they ranged in size from 4 feet by 4 feet to 4 feet by 8 feet and 6 feet by 6 feet. Four were upper lobe panels and two were lower lobe. Both lower lobe panels contained portions of door cutouts. Large panels in the miscellaneous

section were either badly damaged or of typical<sup>3</sup> construction making identification uncertain.

The majority of the remaining pieces were less than 2 feet by 3 feet. The longest detached frame segments were about 4 feet, and the average around 2 feet. Loose stringer segments averaged 2 feet long, close to the 22-inch frame spacing. The majority of the window frames were fractured.

The miscellaneous door pieces contained both door and door surround pieces for cargo, passenger, and landing gear doors. Door stop fittings typically were loose, with less than an inch of the surround structure attached. Cargo door hinges had the hinge pins intact, they were broken free at the attach fasteners. Other items include cargo doorsill rollers, hinge and actuator arms, segments of cutout structure, and door mechanism components.

There was no evidence of fire damage and all fractures were consistent with failures generated by a high-speed impact. None of the fracture surfaces examined exhibited any obvious evidence of pre-existing fatigue. There was some light corrosion damage on parts where the primer and paint were missing.

## 2.2 Wings

The wing pieces were recovered from the East debris field. The composite flight control surfaces were recovered as floating debris. The basic wing structure consists of the left, center and right wing boxes. These were built up from the front spar, rear spar, ribs and top and bottom skins and stringers. The materials in the wing were aluminum alloys. Boeing has the wing divided into four sections: section 11, section 12, section 13, and section 14. Refer to the wing station diagram (Appendix D).

In general, the structural fractures were consistent with high-energy water impact, i.e.; bending, distortion, and tearing. There was no pillow distortion. There was no evidence of foreign impact damage or an inflight fire. There was no evidence of pre-existing corrosion. There were no obvious signs of fatigue damage.

### 2.2.1 Section 11 - center section

The center section is comprised of upper and lower skins, a front spar, rear spar, three spanwise beams and eight longitudinal overwing floor beams. A significant portion of the upper skin was recovered, approximately 60%. The majority of the pieces were small with a few as

---

<sup>3</sup> Typical is referring to the fact that some of the fuselage parts have the same part numbers and can be located many different places on the fuselage.

large as 30 inches long. Approximately 50% of the lower skin was recovered with some pieces as large as 48 inches long.

There were no identifiable pieces of the front spar, or the spanwise beams found. There were a few pieces of the rear spar found. There were only a few small pieces of identifiable pieces of the overwing floor beams found.

### 2.2.2 Section 12 - wing box

The outboard wing box is comprised of upper and lower skins, a front spar, rear spar, side-of-body closure rib, and thirty-six wing ribs. Approximately 50% of the upper and lower skins were recovered. There were many small pieces and a few larger ones. There were five pieces just over 10 feet long, and one approximately 30 feet long. Some of the skin pieces had stringers attached to them. There was a sizeable quantity of wing box stringer remnants recovered. The lengths varied from small to up to 10 feet long.

The front spar segments recovered varied in length, the longest being approximately 3 feet. The rear spar segments recovered varied in length, the longest being approximately 8 feet. A greater portion of the front spar was recovered than the rear spar. The vent scoop rear spar penetration fitting from the left side was recovered. This fitting is located at wing station (WS) 1050, in the surge tank area.

A few heavy front and rear spar terminal fitting and side-of-body joint pieces were recovered including some of the upper and lower skin panel splice fittings at body buttock line (BBL) 97.5. The majority of the side-of-body closure rib fragments recovered were small. Several slightly larger pieces from the aft area of these ribs were recovered.

The majority of the wing box ribs were very light structure. Approximately 25% of the rib pieces were recovered and identified.

The most outboard parts of the wing that were recovered and identified were the left wing tip closure rib and a piece of the right wing rear spar at WS 1100.00. This piece was at wing box rib #35, close to the wing tip.

### 2.2.3 Section 13 - trailing edge

The trailing edge is made up of the fixed trailing edge structure, the spoilers, the inboard and outboard ailerons, the inboard and outboard flaps, the landing gear forward support structure and the landing gear beam. Approximately 10% of the trailing edge of the wing was recovered and identified.

Less than ten fixed trailing edge parts were identified. This included a few fixed ribs, and a flap deflection control rib.

A number of control surface parts were identified. The documentation is as follows:

One outboard aileron segment 35 inches long by 32 inches chordwise had a balance weight tower attached. The balance weight was not attached, and the aileron was severely damaged.

Another outboard aileron fragment was identified and had a small part of the trailing edge rib attached. A 7-inch wide strip of wedge was attached and extended to the aileron trailing edge.

An outboard aileron hinge with part of the aileron spar and fixed trailing edge rib segment was identified.

One inboard spoiler segment 70 inches long by 28 inches chordwise was identified. The front spar of the spoiler and the hinge actuator fittings were missing. The composite spoiler was fractured at the spar with the trailing edge intact.

One inboard spoiler actuator fitting was identified, but the part was broken free of the spoiler panel it had been attached to.

Three separate spoiler hinge fittings were identified, and believed to be spoiler idler hinges.

Approximately 25% of the main and aft flap structure was identified. These parts were significantly fragmented. The flap linkages at positions 1, 2, 3, 6 and 7 were identified and significantly complete. One, position 4 or 5, torque tube was identified. The linkage at position 8 was not found. Some of the linkages had pieces of wing skin still attached to them.

It was estimated that 90% of both landing gear beams were recovered and identified. This included the outboard end lugs and fittings and the inboard end lugs. The drag brace fitting on the left rear spar was found, as was one inboard end swivel fitting. The left landing gear beam had almost all of the outboard end support structure attached to it.

The landing gear forward trunnion H-block fittings and the respective support fittings were identified. Both H-block fittings remained attached to the landing gear trunnions, although the right trunnion was fractured about 10 inches from the forward end. The left H-block fitting had 1 fuse pin sheared (inboard/upper) and 3 pulled out of the support fittings. The right H-block fitting had 2 fuse pins sheared (both upper) and 2 pulled out of the support fittings. The outboard ends of both of the landing gear beams were bent forward.

The only items that were identified as being from the left or right sides of the trailing edge were the flap operating linkages.

#### 2.2.4 Section 14 - Leading edge

A very small quantity of fixed leading edge structure was identified, approximately 1%. This was comprised of a few pieces of sheet metal parts. The slat parts that were identified were three slat structural ribs, and a short segment of an inboard slat. The slat operating components identified were approximately one half of the main tracks, four auxiliary track arms, thirteen auxiliary tracks and a few slat track rollers.

#### 2.2.5 Engine Pylon

This section will cover the pylon structure and the pylon-to-wing attachment fittings, on the pylon side and the wing side. The engine pylon attachment fittings were characterized as follows: upper link fitting, diagonal brace fitting, outboard mid spar fitting, inboard mid spar fitting, and the inboard and outboard side link fittings. Refer to the engine pylon diagram (Appendix E). All of the wing fittings are "split", each having an inboard and outboard half, except the side link. Engine #1 is the left engine and engine #2 is the right engine. Approximately 1% was recovered and identified.

Engine #2 diagonal brace fitting group was identified. This included two segments of the diagonal brace and some additional pieces of the brace. The aft segment had 24 inches of the brace attached to the wing side fitting which is 32 inches long, with the fuse pin still intact. The flanges that bolt to the lower wing skin had a significant portion (20 inches by 24 inches) of lower skin still attached. This piece of skin was bent in an upside down U shape. The forward segment had 24 inches of the diagonal brace attached to the pylon side fitting with the pylon fitting having a piece of the pylon mounting structure still attached. This forward joint had the pin still intact although this is not a fuse pin.

Engine #2 outboard mid-spar fitting group was identified. The wing side had the forward portion of both fitting halves still attached to the pylon side fittings with the fuse pin still intact. Parts of both wing side front spar bathtub fittings were there, but did not include any front spar web. The wing side inboard half of the outboard midspar fitting was fractured into two pieces, 20 inches and 42 inches long. The wing side outboard half of the outboard midspar fitting was 9 inches long, measured from the front of the lug. The pylon side mid spar lug fitting had small pieces of structure attached and extended a total of 23 inches forward including the lug.

Engine #1 wing side inboard half of the outboard midspar wing side fitting was identified. This fitting had the primary forward lug fractured and was not recovered. An additional piece of this fitting's wing skin attach flange was identified.

Two other pieces of wing side midspar fittings were found but not identified as to the exact location. There were no pitchlink or inboard midspar fittings identified.

One 18 inches by 24 inches panel of the pylon/strut structure was found. It is believed to be part of the lower spar but cannot be identified to the exact location.

In general, engine #2 structural fractures were consistent with high-energy water impact, i.e.; bending, distortion, and tearing. Since there were only two pieces of the #1 engine pylon recovered, the mode of failure was not determined for the outboard midspar fitting for engine #1. There was no evidence of foreign impact damage or an inflight fire. There was no evidence of pre-existing corrosion. There were no obvious signs of fatigue damage.

### 2.3 Empennage

The empennage is comprised of the horizontal stabilizer and the vertical fin, along with the corresponding control surfaces. All of the empennage pieces were found in the East debris field.

#### 2.3.1 Horizontal Stabilizer

The horizontal stabilizer consists of an auxiliary front spar, a front spar, rear spar, ribs, skins, and a center section box. The structure aft of the rear spar consists of ribs that incorporate hinge bearings for the elevator. Refer to the horizontal stabilizer diagram (Appendix F). Approximately 25% of the horizontal stabilizer was recovered and identified.

The center section of the horizontal stabilizer is contained within fuselage section 48. The center section consists of upper and lower skin panel assemblies, the front and rear spar, four ribs, a jack screw fitting and two pivot fittings.

The jackscrew was still attached to the upper skin. No pieces of the front spar or lower skin panel were identified. The jackscrew fittings were intact. The fasteners failed at the front spar.

The upper panel was intact from the front spar to the skin splice. The fracture was straight across the skin splice from side to side and failed approximately 12 inches inboard of the splice on the right side. The left side of the center section failed approximately 17 inches outboard of the splice.

The rear spar fractured and two large pieces were recovered with the pivot fittings attached. The left side of the spar fractured approximately one foot inboard of the pivot and four feet outboard of the pivot. The right side of the spar fractured at the inboard side of the side-load fitting (about two feet) and about five feet outboard.

There was no evidence of any pre or post impact fire damage and all fractures were consistent with failures generated by a high-speed impact. There was no prevailing directionality to the failures. None of the fracture surfaces examined exhibited any sign of pre-existing fatigue. There was some light surface corrosion damage on a few parts where the primer and paint were missing.

The outboard stabilizer is made of fixed and moving structure. The fixed structure consists of an upper and lower skin panel assembly, front and rear spar, inspar ribs, fixed structure forward of the main torque box, and fixed structure aft of the main torque box. The moveable structure is made of the inboard and outboard elevators.

The outboard stabilizer upper and lower panels fractured in many small pieces. Most of these pieces were two feet square or smaller and were flat with no stringers attached. There were two larger pieces of upper wing skin that were both approximately three feet to four feet wide by six feet to eight feet long. These pieces were folded in on themselves and had some stringer pieces attached to them.

There were two identified pieces of the fixed leading edge. One piece contained the right side logo light housing and was approximately 2 feet by 4 feet. The other piece was the left and right horizontal strakelet. There were no identified pieces of the outboard front spar of the horizontal stabilizer. The rear spar supports the actuators and the hydraulics for the elevator. The largest piece of the rear spar had the outboard actuators still attached. For more information on the actuators, refer to the Systems Group Chairman's Report. This piece of rear spar and fixed trailing edge was approximately 84 inches long and also had two elevator pivots as well as the actuator rod ends and pivot fitting. There was evidence that the pivots traveled past both the up and down maximum designed travel limits. The grease fittings were broken off from both the inboard and outboard pivot fittings and there was damage to the outboard fitting where it struck the grease joint. There was also evidence of impact damage on the actuator fitting. These actuation mechanisms were the most outboard items identified on the horizontal stabilizer for the right side. The left horizontal tip was the most outboard piece identified for the left side.

The elevators consist of an inboard and outboard elevator on the left and right side. The inboard and outboard elevator are normally joined together by an aft main fitting and a secondary forward fitting. The inboard left elevator was recovered floating and was almost intact. The outboard pivot fitting was still attached to the elevator and there were signs of impact on both the upper and lower surface that match the elevator pivot. The rest of the elevators were in pieces too small to identify with the exception of one small piece of the right side inboard



elevator. This piece contained part of the forward fitting that joins the outboard to the inboard elevator. This part fractured in a similar fashion on both the left and right sides. There was no evidence of fatigue in any of the fittings that join the inboard and outboard elevator. There was one complete fitting recovered from the main joint that links the inboard to the outboard elevators. It was determined to be the fitting from the left side. A total of four actuator and seven hinge fittings were recovered. The fittings typically have a portion of the elevator spar attached and a portion of the stabilizer fitting. Four fitting locations had contact damage due to downward elevator travel. The damage was near the zerk fittings, with two zerk fittings broken. One location also had contact damage due to up elevator overtravel.

There was no evidence of any pre or post impact fire damage and all fractures were consistent with failures generated by a high-speed impact. There was no prevailing directionality to the failures. None of the fracture surfaces examined exhibited any sign of pre-existing fatigue. There was some light surface corrosion damage on a few parts where the primer and paint were missing.

### 2.3.2 Vertical Fin

The vertical fin consists of an auxiliary front spar, a front spar, a rear spar, ribs, and skins. The fin attaches to fuselage section 48 at four frames. The structure aft of the rear spar consists of ribs that incorporate hinge and actuator attachments for the rudder. Refer to the vertical fin diagram (Appendix G). Approximately 20% of the vertical fin was recovered and identified.

The largest piece of the vertical fin identified consisted of the lower quarter of the rear spar along with a piece of the section 48 bulkhead and skins. The fin rear spar segment was 135 inches long. The upper 25 inches was separated and it contained the hinge rib for the rudder at rudder station 106. The rudder hinge joint was intact and the rudder hinge fitting was attached. The right side flange of the hinge fitting common to the right rudder skin was missing. Strips of the fin skin panels were attached to the lower portion of the spar. The left spar chord was fractured at the root of the radius on the upper half of its length. Three rudder PCA units had the fin attach fittings attached. The fittings were torn free of the spar with only fragments of the spar present.

The right portion of the two fin attachments between the front and rear spar were present. The attachment at station 1678 is 15 inches wide and 83 inches long. The attachment at station 1702 is 15 inches wide and 40 inches long. Both have the tension bolt and barrel nut joint intact and contain portions of the section 48 bulkheads.

There was a portion of the fin leading edge measuring 63 inches in length, which included the full section and a piece of the auxiliary spar. This segment was bent and twisted with the skin fractured adjacent to the front spar. A lower leading edge nose rib was attached. A 2 feet x 6 feet piece of the vertical fin just above the EgyptAir logo was recovered.

A number of smaller fin pieces in the 2 feet by 3 feet size range were present. All of the pieces identified were from the lower half of the fin. There was no evidence of fire damage and all fractures were consistent with failures generated by a high-speed impact. None of the fracture surfaces examined exhibited any obvious evidence of pre-existing fatigue. There was no evidence of pre-existing corrosion.

The rudder attaches to the fin at nine locations and is driven by three PCA's. The rudder is constructed of composite materials. Approximately 15% of the rudder was recovered and identified. The largest piece of the rudder identified was 39 inches wide by 55 inches tall. It contained the right and left skins and portions of two ribs. The skins were joined at the trailing edge, but the spar element was missing. This segment was estimated to be from the middle of the rudder length by the color scheme. Five rudder hinge fittings and three actuator fittings were found. All of the hinge pins were intact. The depth of the rudder spar of the narrowest fitting (the highest on the tail) was 9 3/8 inches. Other rudder pieces found were small fragments.

There was no evidence of fire damage and all fractures were consistent with failures generated by a high-speed impact. None of the fracture surfaces examined exhibited any obvious evidence of pre-existing fatigue. There was no evidence of pre-existing corrosion.

#### 2.3.4 Miscellaneous Tail

There was a small amount of wreckage that was recovered and identifiable as being part of the tail section but not the exact location, approximately 5%. These pieces were collected in a separate area.

### 2.4 Landing Gear

The landing gear consists of two main landing gears and a nose gear. The main landing gear has a truck assembly that holds four tire/wheel/brake assemblies, for a total of eight. The nose wheel has two tire/wheel assemblies. The landing gear was recovered from the East debris field.

#### 2.4.1 Main landing gear

The left main landing gear outer cylinder separated into five major pieces. The two lock springs and two jury strut springs were recovered

and exhibited compression damage. Approximately 70 % of the left main landing gear was recovered.

The right main landing gear outer cylinder only had two major pieces recovered; the upper and lower half. The areas where the side brace and drag brace attach were missing. The two lock springs and two jury strut springs were recovered and exhibited compression damage. The upper and lower torque links were still attached to the outer cylinder. The brackets for the rod end and truck positioner were still attached. Approximately 80% of the right main landing gear was recovered.

A retract actuator was recovered but it could not be identified as left or right. Pieces of a drag brace and a side brace were also recovered. Both forward trunnion fittings exhibited signs of deformation in the fore to aft direction, the trunnion holes were elongated.

#### 2.4.2 Nose landing gear

There were only sixteen small pieces of the nose landing gear identified from the recovered wreckage. The pieces were from the drag brace, forward and aft doors hinges, the lock springs and the uplock. The average sized piece was 4 inches. The springs were pulled in tension. Approximately 5% of the nose landing gear was recovered.

#### 2.4.3 Tire, Wheel, and Brake Assemblies

As part of the cargo there were two main and one nose landing gear tires, for a total of thirteen tubeless tires. One main and one nose landing gear cargo tires were recovered. These tires were identified as cargo tires due to the lack of damage and being recovered as part of the floating debris. There were a total of eleven tires recovered.

Four of the tires still had the wheel and brake assemblies attached. Four brake and partial wheel assemblies were recovered separately, so that all of the main landing gear brake assemblies were accounted for.

Tire s/n 495WD198, wheel s/n 4038 was a main landing gear tire and wheel assembly with the brake assembly separated from the wheel. The tire was missing  $\frac{1}{4}$  of its outer core.

Tire s/n 3112N00745, wheel s/n 2348, brake s/n 1985 was a main landing gear tire and wheel assembly which had approximately  $\frac{1}{3}$  of the truck beam still attached. The truck positioner lug was broken. Half of the equalizer rod was still attached. The brake quick disconnect was still attached. The axle for the opposite tire was still attached and in good condition. The outer core had numerous lacerations and  $\frac{1}{2}$  of the outer core was separated.

Tire s/n 395WD107, wheel s/n 5313 was a main landing gear tire that was cargo. This tire was in good shape and had very little damage to it.

Tire s/n 201006653, wheel s/n 2832 was a nose landing gear tire and wheel assembly that was cargo. This tire was in good shape and had very little damage to it.

Tire s/n 595WDO73, wheel s/n 2659, brake s/n unidentifiable was a main landing gear tire and wheel assembly. The tire had numerous lacerations to the outer core. The wheel assembly had little damage and a small amount of salt-water corrosion. The brake assembly was still attached to the wheel assembly but was pushed outboard approximately six inches. The fan was still attached. Half of the equalizer rod and half of the axle were still attached.

Tire s/n 395WD131, wheel s/n 5307, brake s/n 1575B was a main landing gear tire and wheel assembly. Half of the equalizer rod and 1/3 of the truck beam was still attached. The fan was still attached. The tow lug was broken off.

Tire s/n 395WD130, wheel s/n 5274, brake s/n 1722 was a main landing gear tire and wheel assembly. Half of the equalizer rod and the axle were still attached. There was no truck beam. There were numerous lacerations to the outer core of the tire. Approximately 1/3 of the outer core was separated but still attached.

Tire, s/n unidentifiable, was a main landing gear tire outer core. The tire was missing half of its outer core. Goodyear was the manufacturer.

Tire, s/n unidentifiable, was a main landing gear tire outer core. The tire was missing 3/5 of the outer core. Bridgestone was the manufacturer.

Tire, s/n 495WD195, separated into five pieces. Bridgestone was the manufacturer.

Tire, s/n unidentifiable, was a nose landing gear outer core. The inner diameter was how this tire was identified as a nose landing gear tire. Only two pieces were recovered, one being 2 feet long and the other 2 ½ feet long. Goodyear was the manufacturer.

Brake assembly, s/n 1986, was found with the majority of the wheel housing, s/n 2697, still attached plus half of the axle.

Brake assembly, s/n 1907, was found missing 1/3 of the outer brake assembly. This brake assembly also had 1/3 of the wheel assembly, s/n 5309, plus half of the axle still attached. The missing 1/3 of the outer brake was found with half of the equalizer rod attached.

Brake assembly, s/n 1777, was found with wheel housing and axle missing.

Brake assembly, s/n 1706, was found with 1/3 of the wheel assembly, s/n unidentifiable, and half of the axle attached. The disks were separated from the brake assembly. Fifteen small pieces of brake disks were recovered, approximately 3 to 4 inches in size.

There were twenty-one pieces of fractured main landing gear wheel recovered, varying in size from 2 inches to 6 inches. There were two loose equalizer rods that were broken in half. Five loose fans were recovered. Two of the fans were in good shape while three of the fans had suffered impact damage.


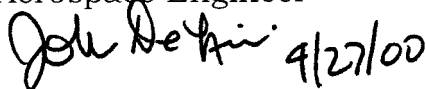
Two nose landing gear wheel assemblies were recovered. Both of the nose landing gear wheels serial numbers were unidentifiable. One of the wheels was broken open with just the housing bolted together. Half of the housing was missing. The other wheel had half the axle still attached with the nut. The nut was locked down with two remaining bolts. Approximately 1/3 of the wheel housing was missing.

#### 2.4.4 Tail Skid p/n 163T100-2, s/n 0044

The tailskid is a retractable shock strut that protects the underbody of the airplane from damage caused when over rotation occurs during takeoff or landing. Hydraulic pressure is required to keep the tailskid in the fully retracted position. The tailskid was separated from the tail and was in the retract position. The actuator outer cylinder was cracked and had an opening of 2 inches by 1 inch near the top. The cables were still attached to the tailskid and had 3 inches by 3 inches sections of the tail attached to the other end. The hydraulic hoses on the forward side of the tail skid was still attached but the aft hydraulic hose was torn from its fitting.

#### 2.4.5 Doors

Door hinges from both the nose and main landing gear were recovered.

  
Lorenda Ward  
Aerospace Engineer  
 9/27/00